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Title: Five rad things you can do with an “atom smasher”

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Five cool things you can do with an "atom smasher"

By Bruce Carlsten

Early in the 20th century, scientists began to unravel the atom's inner workings, discovering tiny particles like protons, neutrons and electrons. To better understand how these particles work, pioneer scientists developed and built "atom smashers," huge machines that accelerate particles to near the speed of light and crash them into each other at extremely high energies.

Today, accelerators are common in various places, from hospitals, where they create particles for medical imaging and treating diseases, to world-class research laboratories, where they continue to explore how the universe works at the smallest scale.

Los Alamos National Laboratory has several accelerators peppered throughout its 43 square miles. By far its largest is the accelerator at the Los Alamos Neutron Science Center (LANSCE). The most powerful linear accelerator in the world when it opened in 1972, LANSCE speeds protons, one of the basic building blocks of atoms, to 84 percent the speed of light and energies as high as 800 million electron volts. The protons traveling down the accelerator are moving a trillion times faster than a mosquito traveling down the same accelerator—that's a pretty big deal. Protons are very light, so each one carries very little actual energy, but there are so many that together they deliver nearly a megawatt, one million watts, of average power to targets at the end of the accelerator.

Scientists primarily use big accelerators to conduct basic research into the fundamental mysteries of the universe, but work done with these machines also improves our daily lives. The following are five cool things produced today at accelerators around the world.

1. Cooling down neutrons to study nature's hidden secrets

Connected to the LANSCE accelerator is the Ultracold Neutron facility, which uses the accelerator to produce high-energy neutrons. Along with protons, neutrons make up an atom's core, the nucleus. Neutrons do not have an electric charge—they are neutral. Scientists use a heavy form of hydrogen to slow neutrons produced by LANSCE by one million billion fold to only a few meters per second and then trap the slow neutrons in a magnetic "bathtub."

By slowing down neutrons, scientists can make unprecedented measurements and conduct experiments about their properties, like how long a neutron takes to decay. Indeed, Los Alamos scientists have calculated the most precise "lifespan" of the neutron. Such measurements and experiments could help answer questions associated with the fundamental constants of nature, such as how the universe was originally formed.

2. Producing medical isotopes to diagnose and treat cancer

Accelerators make radioisotopes, which play a key role in various applications, one being nuclear medicine. A radioisotope emits radiation that can be used to diagnose and treat various diseases. LANSCE makes various isotopes, including one used to treat approximately 30,000

cardiac patients per month—it's that common. Los Alamos is transferring work on medical-imaging isotopes to industry while scientists shift their attention to advanced research to push the use of radioisotopes for medical applications even further. For example, isotopes are being developed to battle cancer by destroying targeted cells in tumors.

3. Designing new materials

Accelerators are used to make materials stronger through ion implantation. This process uses an accelerator to smash electrically charged elements known as ions into a solid target, thus changing the target's physical, chemical or electrical properties. Accelerators can also be used to develop detectors for nondestructive testing, which can be used, for example, to inspect bridges to see if they have minute cracks or other imperfections that in time could lead to disaster. LANSCE instruments can also characterize manufacturing flaws nondestructively in materials such as tungsten.

Physicists use electron accelerators to create high-energy X-rays capable of penetrating the very nature of matter. With these incredible light sources, it is now possible to make movies of molecules as they move and flex and take still images of chemical reactions. That lets scientists study them at precise moments in time and examine the very structure of matter so researchers can, for example, find ways to make materials stronger, more flexible or more damage resistant.

4. Creating new nuclear reactors and fuels

Although scientists have made inroads with alternative energy sources like wind and solar, nuclear energy remains a viable option for energy production. LANSCE scientists, working through the Department of Energy's Advanced Fuel Cycle Initiative, are developing new classes of nuclear reactors and new types of fuels. Using instruments attached to LANSCE, scientists can characterize nuclear fuels and find ways to make them safer and cleaner. Safe and cleaner reactors and fuel will help decrease America's production of greenhouse gases. Also, scientists are designing new reactors based on fuels that cannot be used in nuclear weapons, greatly reducing the chances of the fuel being stolen for its possible use in nuclear terrorism.

5. Taking exotic images

In 1998, paleontologists discovered a 74-million-year-old fossil of a distant relative of a tyrannosaur. Although the outside of the skull looks impressive, what it looked like from the inside proved elusive, as it was a chunk of solid rock. Conventional X-ray machines could not penetrate it.

The New Mexico Museum of National History and Science brought the skull to Los Alamos, where scientists used the LANSCE accelerator to create a beam of high-energy neutrons capable of going where X-rays can't. The resultant scan of the skull revealed startling internal details, such as unerupted teeth, brain and sinus cavities, the internal structure of some small bones and even pathways where nerves and blood vessels once traversed to give the tyrannosaur life.

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Founder Louis Rosen looks at a model of the Los Alamos Meson Physics Facility, which is now known as the Los Alamos Neutron Science Center. (Los Alamos National Laboratory photo)

These injectors at the Los Alamos Neutron Science Center create the high-energy particles for the beam used to explore the basic properties of matter. (Los Alamos National Laboratory photo)